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Manufacturing Education- Facilitating the Collaborative Learning Environment for Industry and University

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Abstract

State of the art Engineering Education is crucial for Research and Innovation according to the European Union's growth strategy. This paper contributes with more knowledge of how Universities and Industry can facilitate collaborative learning environments and create efficient working methods. A group of students accepted the challenge from an industrial company to examine robotic assembly of their products. The students built a robot cell prototype in the company's design department, to promote knowledge about design for robot manufacturing. The setting of this learning environment enabled knowledge creation with significant learning outcomes for the university, the Industrial Company and other partners. The project motivated the teachers to collaborate across Faculties at the University, and gave new insight in formulation of objectives for this type of projects.

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1. Introduction

Europe 2020 [1], the European growth strategy and the Horizon 2020 [2], the European framework for research and innovation, highlight demand for turning research into innovations. In order to achieve the ambitious objectives, emphasis is placed on increasing the innovation that comes out of cooperation between education, research and business organizations. Universities are challenged to take a leading role in building effective links between research, education and innovation, the dimensions in the Knowledge Triangle (KT) [3] . The European Society for Engineering Education (SEFI) [4] and International Association for Contributing Engineering Education (IACEE) [5] have put much effort into investigating how research, education and innovation can create this Knowledge Triangle together [3].

One of the key success factors in the Knowledge Triangle is "orchestration" of collaborative platforms and operations within the many interfaces of university-industry collaboration [3]. It means that there is a need for an efficient structure for collaboration including facilitating work procedures, coordinating the processes and supporting the all stakeholders' interests in order to achieve productive outcomes.

Another key factor is the need for a serious cultural transformation of universities organizations [6]. In order to meet the Europe 2020 targets, the paradigm shift from individual to open innovation must be effected immediately. For universities, it means the massive transition from working in traditional silo structures to collaborative working organizations.

A third key factor is the claim that there are differences between universities and industrial companies when it comes to setting the projects' goals and the ways in which the projects are carried out in Small and Medium Sized Enterprises [6]. The academic culture focus publication of scientific papers and reports, and but the industrial organization strives for business results.

This research work aims to contribute more knowledge regarding the three key factors mention above, more precisely:

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a) Collaborative Learning Environment and efficient working methods
b) Cultural transformation of university organization
c) Project goal settings and project execution

This research work elaborates these scientific issues through a case study of a collaborative project between the Norwegian University of Science and Technology in Aalesund (NTNU Aalesund) and an Industrial Company. The project lasted for five months and delivered significant learning outcomes for the university, the students, the company and the regional industrial network. The project had several original aspects that contributed to its success and therefore the case deserves to be presented to a wider audience. Firstly, students were not only involved in the collaborative project; they were assigned the leading role of the project, with lecturers acting as supervisors. The student group and lecturers represented different engineering departments, providing a variety of competences that helped to inform into project. During the project's progress, students initiated involvement with external companies that had a required specific competence. This contributed to the growth of the network and strengthened the regional innovation ecosystem.

The unique setup of the learning environment – undertaking the student project in the company's premises – fostered knowledge creation processes that provided significant learning outcomes for the university, the Industrial Company and Suppliers involved in the project. To understand why undertaking a student project in an industrial environment was so effective, the article studies the knowledge creation processes in this case from the Japanese perspective of a knowledge creation model.

2. Nonaka's et al. knowledge creation model

There are two kinds of knowledge: tacit and explicit. Explicit knowledge is defined as theoretical knowledge that is formulated in documents such as manuals and drawings. Tacit knowledge can be understood as practical knowledge. This kind of knowledge is linked to an individual's experiences such as working routines, bodily movements, values and emotions [7]. Tacit knowledge can be hard to formalize and to communicate to others, but when it is actualized, it becomes explicit [8]. Operators, for instance, can formalize their tacit knowledge through operational instructions by making what they know explicit. Utilizing the tacit knowledge of employees is an important and demanding task in a knowledge-creating company. The challenge li**e**s in enabling tacit knowledge. Therefore Nonaka et al. [9] have proposed the necessity of an enabling context known as 'ba', meaning 'place' in Japanese. 'Ba' supports the knowledge creation processes, because knowledge needs a context or place in which to be created. The enabling context, 'ba', is a "knowledge space" that can be physical, virtual, and mental or even a combination of some or all of them. The essence of 'ba' is interaction. Through interaction between individuals or individuals and their environment, knowledge can be generated. [8]. A typical 'ba' or knowledge context is any kind of meeting where individuals can share their experiences, emotions and mental models.

Based on their studies of Japanese industry, Nonaka et al. found that organizations create knowledge through the four models of knowledge transformation that are mainly based on interactions between tacit and explicit knowledge: Socialization, Externalization, Combination and Internalization. A combination of these four models is called the SECI processes. Knowledge transformation should be thought of in a circular manner because it is targeted at enhancing the knowledge-creating potential of the organization. The Nonaka's model of the SECI processes is illustrated in Figure 1.

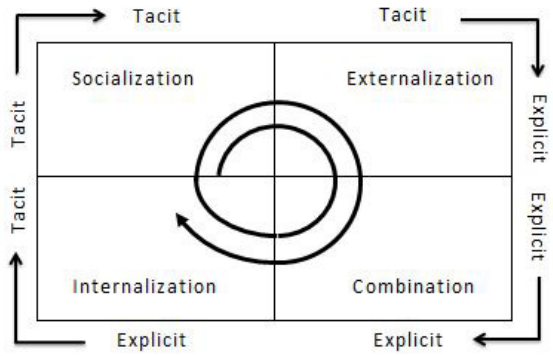

Figure 1. The SECI processes [9]

The core of each of the four models is as follows:

- Socialization - is the process of acquiring new tacit knowledge through shared experience or conversations. It can be experience gained while working or living together in the same environment. For instance, apprentices learn tacit knowledge by working alongside experienced workers [9]. Socialization also means sharing thoughts, ideas, and experiences through communication. For instance, salespeople can develop a new perspective on their products by interviewing the customers. Socialization is an inevitable platform in creating mutual understanding and trust between people that makes the exchange of tacit knowledge effective.
- Externalization – is the process of making tacit knowledge explicit. This typically involves face-to-face interaction when people exchange their visions and work out a common mental model. Concept development is a characteristic of externalization.
- Combination – is the process of converting explicit knowledge into combinations of explicit knowledge. Explicit knowledge is collected from formalized internal and external sources and then it is put together in a new context. One example of this is the integration of data about examination grades in different faculties into one statistical report for a university. Another is collecting information from media, technical data and experts to build up the material needed to make a prototype.
- Internalization – is the process of turning explicit knowledge into tacit knowledge. The internalization of